Welcome to the Huberman Lab Podcast, where we discuss science and science-based tools for everyday life. I'm Andrew Huberman and I'm a professor of neurobiology and ophthalmology at Stanford School of Medicine. Today I have the pleasure of introducing Dr. Duncan French as my guest on the Huberman Lab Podcast. Dr. French is the vice president of performance at the UFC Performance Institute, and he has over 20 years of experience working with elite professional and Olympic athletes. Prior to joining the UFC, French was the director of performance science at the University of Notre Dame. And he has many, many quality peer-reviewed studies to his name, exploring, for instance, how the particular order of exercise, whether or not one performs endurance exercise prior to resistance training or vice versa, how that impacts performance of various movements and endurance training protocols, as well as the impact on hormones, such as testosterone, estrogen, and some of the stress hormones, such as cortisol. He's also done fascinating work exploring how neurotransmitters, things like dopamine and epinephrine, also called adrenaline, can impact hormones and how hormones can impact neurotransmitter release. What's particularly unique about Dr. French's work is that he's figured out specific training protocols that can maximize, for instance, testosterone output or reduce stress hormone output in order to maximize the effects of training in the short term and in the long term. So today you're going to learn a lot of protocols, whether or not you're into resistance training or endurance training, you will learn, for instance, how to regulate the duration of your training and the type of training that you do in order to get the maximum benefit from that training over time. So whether or not you are somebody who just exercises recreationally for your health, whether or not you're an amateur or professional athlete, or whether or not you're just trying to maximize your health through the use of endurance and or resistance training, today's discussion will have a wealth of takeaways for you. There are only a handful of people working at the intersection of elite performance, mechanistic science, and that can do so in a way that leads to direct immediately applicable protocols that anybody can benefit from. Dr. French also provides some incredibly important insights about the direction that sport and exercise are taking in the world today and their applications towards performance and health. Before we begin, I'd like to emphasize that this podcast is separate from my teaching and research roles at Stanford. It is however part of my desire and effort to bring zero cost to consumer information about science and science related tools to the general public. My conversation with Dr. Duncan French. Duncan French. Great to see you again. Likewise. Likewise. Thank you. I don't often have many Stanford professors in the performance institute, so I'm really excited. This place is amazing, and you have a huge role in making it what it is. The reason I'm so excited to talk with you is that you're one of these rare beasts that you have been involved in human performance and athletic performance at the collegiate level. You are obviously very involved in MMA now in the UFC Performance Institute, and you also had the fortunate experience. I like to think of doing a PhD in what exactly was the PhD in? It was exercise physiology. So you're familiar also with designing studies, control groups, all the sorts of things that in my opinion, in any way are lacking from the internet, social media version of exercise science, which is very important. It's a very important exercise science, which is that people throughout all sorts of ideas about how people should be training what they should be doing and eating and not eating and doing. And certainly science doesn't have all the answers, but I just think it's so rare to find somebody that's at the convergence of all those different fields. And so I have a lot of questions for you today that I'm sure the audience are going to be really interested in it. Well, listen, I mean, I appreciate that. It's very humbling. And yeah, I've worked hard to get to where I am. But I've always tried to be authentic. And I think authenticity comes alongside, you know, an academic rigor and objectivity and insight and knowledge base, right? At the end of the day, it's about having confidence, having expertise and being able to deliver that expertise to in my world to athletes. And I think that's what I've always tried to do. I've tried to have many strings to my bow so that I can talk with many different hats on, you know, one day I'm talking to a coach, next I'm talking to an athlete, the next day I'm talking to a CEO, the next day I'm talking to an academic professor. And so I think, you know, being able to wear those different hats is certainly a skill set that I've tried to build throughout my career. And, you know, like I said, I've been blessed to work with, I think it was 36 different professional or Olympic sports last time I've counted. So yeah, it's been a wild ride. It's been great. Which of those sports was the most unusual? It was a good one with crown green bowling, which I don't know as an American guy. I don't know. I'm well known. That part of it. Basically imagine a, you know, a 20 foot by 20 foot square of turf with a small raise in the middle, IE the crown. So it slopes to the edges. And, you know, you use, you throw out a white jacket, a smaller ball and then you roll out larger balls to try and get closest to the jacket. It's a very European thing. But yeah, sports performance, a crown green ball and there you go. All right. Wow. And then to a mixed martial arts fighter. Absolutely. And everything in between. So along those lines, could you give us a little bit of your background? Where'd you start out? Where are you from originally? Yeah, I'm from the northeast of England. So I'm from a town called Harrogate, which is in Yorkshire, which is a northern kind of area of the... Nice sunnier....other all year long. Yeah, you can imagine. Yeah, with the two weeks of summer that we get, you know. But yeah, I mean, I did my, my undergraduate studies there in sports science. I did teacher training to be a physical education teacher after that. Like most people are then, you know, worked as a high school physical education teacher. You know, great experience working with kids, you know, developing, you know, athletic qualities. But something in the back of my mind always, you know, I wanted more. I wanted to be, you know, to be at the higher end of elite sport. You know, I was a failed athlete like many people. Like I'm representing my country in different sports and things, but I never made it professionally. So, you know, that little seed was sown in as much as I then started to reach out to, you know, to different areas to do a PhD, whether it was in the UK or also, you know, chance my arm took a punts if we could get over to the States. And all my buddies were going on, you know, gap years after the Finnish university or whatever and going to Bali and hanging out or whatever traveling through Thailand. And I figured, well, you know, I always love the States and kind of go and kill two birds with one stone and do something academic, continue my studies, but also doing a different environment and get some life experience. And then many, many rejections as I'm sure you're kind of aware from different professors, whether it's Roger or Nookur or, you know, William Kramer. You just wrote to these folks. I just called, called, called and sent out information and said, yes, so we got any opportunities, push back from more, but, you know, dogged and kept kept asking and, yeah, Dr William Kramer, who was at Ball State University in Indiana at the time, you know, a muscle, you know, you know, you're basically sad, listen, I can guarantee you funding for the first year of your studies, but not the next three sounds like a typical academic response. I can take care of you, but not that well necessarily. Yeah. So I spoke to my parents and said, hey, can we, can we take a point and they were great in supporting me. And yeah, long story short, came out to to begin my PhD at Ball State after a year, Dr Kramer transferred to Yukon, Connecticut, in stores in the Northeast there and transferred to him and with him. Yeah, four great years with Matt with my PhD and getting my PhD with a really prolific research group that looked at, you know, neuroendocrinology, hormone work, but using resistance training primarily as an exercise stresser, as a major mechanism and then looking at all the different physiologies off the back of resistance training. You guys were enormously productive. I found dozens of papers on how weight training impacts hormones and your names on all of them. And it's remarkable. I have a question about this. I'll just inject a question about weight training and hormones. You hear this all the time that doing these big heavy compound movements or resistance training increases, and your endogenes, things like testosterone, DHT, DHA and so forth. Does anyone know how that actually happens? Like what about move, what about in what is it about engaging motor neurons under heavy loads sends a signal to the endocrine system. Hey, release testosterone. I've never actually been able to find that in a textbook. Yeah, well, I mean, and how can I do more of that? As much as I know, you know, and again, I'm digging into the annals of Duncan French is kind of brain now, but yeah, I mean, I think it's a stress response, right? It's mechanical stress and it's metabolic stress and these are in a downstream regulation of testosterone release at the gonads comes from many different areas. You know, they're my work primarily looked at, you know, catacolomines and sympathetic arousal. So they're like epinephrine adrenaline, you know, and noradrenaline. How they were signaling that sign in cascade using, you know, the HPA axis releasing cortisol and then, you know, looking at how that also influenced the adrenal medulla to release. You know, androgens and then signaling that the gonads there is an interesting question. So in presumably weight training in women, people who don't have testes, also it increases testosterone. Yeah, is that purely through the adrenals when women lift weights, there are adrenal glands release testosterone. Absolutely. I mean, that is the only area of testosterone release for females. And yes, it's the same downstream cascade. The extent to which it happens is significantly less than females, but that's how you, there's good, good data out there that shows, you know, females can increase their anabolic environment. They're internal anabolic milieu using resistance training as a stressor and then they get the consequent muscle tissue growth, you know, whether it's tendon ligament adaptations, you know, the beneficial consequences of resistance training, which is driven by anabolic stimuli. I have two questions about that. The first one is something that you mentioned, which is that the, the androgens, the testosterone comes from the adrenals under resistance loads in women is the same true in men. I mean, we hear that the testes produce testosterone when we weight train for men that have testes. But, do we know whether or not it's the adrenals or the testes in men that are increasing testosterone? Yes, I think more both a little bit from each. The field is divided presently. I mean, as much as understanding the acute adrenergic response in terms of, you know, anabolic response to exercise in an acute phase and the exposure to, you know, a stimulus that is stress driven, which might be partly from the adrenal glands, partly from the gonads, versus a longitudinal exposure to anabolic environments, which is primarily driven by the endocardial. The endocrine environment from, from testosterone release at the gonads. So this, the field is split in terms of how exercise is promoting hypertrophy, you know, muscle tissue growth. And whether that is very much an adrenals stimuli, or if that's significant enough in these acute responses versus the longitudinal exposure, just elevated basal levels of anabolic testosterone, a virtual level. So it sounds like a most like with most things is probably both. It's probably an adrenals and the gonads. And then you mentioned that testosterone can have enhancing effects, growth effects on tendon and ligament also. That you don't often hear about that. People always think, you know, testosterone muscle, but testosterone has a lot of effects on other tissues that are important for performance it sounds like. Yeah, yeah, absolutely. I mean, I think, you know, the testosterone hormone is, I mean, listen, there's anrogen receptors on neural tissue on neural axons. Pretty much everywhere. Exactly. So, you know, the binding capacity of testosterone and influence in different tissues within the body had touched on, you know, muscle tissue, but, you know, the ligaments, the tendons, even bone to some extent, you know, testosterone is potential to influence that. And in terms of removing osteopenic kind of characteristics, et cetera. So, yeah, it's a, it's a, it's a magic, magic hormone, let's say, and with many, many and impacts in terms of adaptation. I definitely want to get back to your trajectory, but as long as we're on the interactions between androgens, testosterone and its derivatives and different tissues, you know, from the work that you did as a PhD student and, and throughout your career. I mean, I think that there's a, there's some general principles of training that favor testosterone production in terms of that, that somebody who's not an elite athlete could use somebody who's already adapted to weight training somewhat like they know the difference between a dumbbell and a barbell, and they know they know the various movements, they're not going to damage themselves. But once they're doing that, I mean, I've heard shorter sessions are better than longer sessions, but in rep loads with that there's a lot of parameter space. But if you were going to throw out some of the parameters that you think are most important to pay attention to for the typical person who's trying to use weight training to build or maintain muscle, yeah, lose body fat, so body recomposition, and or stay strong and healthy for sport of a different kind. So the work that we obviously, you know, I was exposed to back in my PhD, it was a double edged sword and as much as testosterone is really stimulated by an intensity factor and also a volume factor. Now growth hormone is a little bit different. That's largely driven by an intensity factor alone. Oh, really? I ever thought that growth hormone was driven by volume, which just goes to show you, maybe I've got no, no, no, I think you're probably right, which just goes to show you that most of what's out there on the internet, right? Not only is it wrong, it's usually backward. So no, trust, I, I know trust your instinct because because I think people just make this stuff up, right? Because it's very hard to measure growth hormone into testosterone and and I can't imagine most of the stuff that I see out there, they're taking drips and, you know, measuring free versus bound and all this kind of stuff. But that's what you do in laboratories. You look at total composition and you look at how much of that is free circulating in the system, how much is bound and therefore biologically active bound to receptive creating adaptation. But yeah, coming back to testosterone in terms of the training strategies, it's largely driven by both an intensity and a volume factor. So if you look at many of the exercise interventions that we use to try and investigate and interrogate testosterone, it was, it was usually, you know, a six by 10 protocol. You touch in six by 10 meaning six sets of 10 repetitions, which is quite a large, you know, 60 repetitions is quite a large volume for a single exercise. And that was usually pitched to about 80% intense over one repetition max intensity. Okay, so 80% of the one rep max six six sets of 10 reps separated by rest of like two minutes, two minutes, which is actually pretty fast, at least to me. Anytime you see these two to three minutes when you're actually watching the clock, those two minute respirators go by pretty fast. By the third fourth set, you're dying for more. Yeah. And I think, you know, we, you know, we formulated that kind of exercise protocol to really target, you know, the release of testosterone and try and drive up these anabolic environments to study the endocrine consequences. But I think that's, that's the type of protocol that is most advantageous for driving anabolic environment. And that was it for the workout. Yeah, I mean, we would do that in a back squat. So, you know, multi joint, you know, challenging exercise, multi muscle multi joint 80% load of your one repetition max and then six by 10. We did play around with, you know, you classic German volume type 10 by 10 kind of protocols. But they were just unsustainable at that 80%. The key to what we also did was we always adjusted the loads to make sure that it was 10 repetitions that were sustained. So if the load was too, too high, and an athlete or a participant had to drop the weights on the sixth repetition, we would unload the bar and make sure they completed the 10 repetitions, bringing me back to the point of it's an intensity and a volume derivative that is going to be most advantageous for testosterone really. That's really interesting. And one thing that you mentioned there is especially interesting to me, which is you said when you go from six sets of 10 repetitions to 10 sets of 10 repetitions, it's not as beneficial and might even be counterproductive. But to me, the difference between six and 10 sets is only four sets. It doesn't even sound that much. So that sort of hints at the possibility that the thresholds for going from a workout that increases testosterone to a workout that diminishes testosterone is actually a pretty narrow margin. Yeah. And I think it comes back to that intensity factor then, you know, what we saw with that 10 by 10 protocol really sees pretty significant drop offs in the load. And again, we're trying to stimulate with intensity with mechanical strain through intensity as well as metabolic strain through volume. And I think that's the paradigm that you've got to look at is that the mechanical load has to come from, you know, the actual weight on the bar and the volume is the metabolic stimulus. How much are we driving lactate? How much are we driving, you know, glycogenesis in terms of that type of energy system for, you know, executing a 10 by 10 protocol. And what we often saw was just a significant reduction in the intensity capabilities of an athlete to sustain that. So we shortened the volume to try and maintain the intensity. Interesting. And you could imagine just taking very long rest, keeping the session being a big lazy bearer and training. I sometimes do this. I tell myself I'm going to work out for 45 minutes and then two hours later I'm done, but not because I was huffing and puffing the whole time, but because I was training really slowly. Is there any evidence that training slowly can offset some of the negative effects of doing a lot of volume? Well, it's an old adage of, you know, two responses to your question. I mean, the first one I would say, you know, there's a difference between 10 sets of six and six sets of 10. And I think that comes back to the volume conversation, you know, six sets of 10 is driving or metabolic stimulus. If you're doing 10 sets of six, you can probably take it to higher intensity, but you're not going to get the same metabolic load. You're not going to get the same internal metabolic environment that drives the lactate release that they will then signal, you know, further anabolic testosterone release because of the lactate in your body. That's a key consideration. The rest is often the consideration that's overlooked out there in general population and in many sports and environments. You know, the rest is as important a program invariable as the load and the intensity, the intensity, the load, the volume, etc. And yes, if you remove, if you extend the volume, if you extend the duration of your rest periods, what you're ultimately doing is influencing that metabolic stimulus again. You're allowing the flushing of the body, the removal of waste products, you know, lactate to be removed from the body and then the metabolic environment is reduced. So if I understand correctly, you want to create a metabolic stress. So the way that I've been training slow and lazy is not necessarily the best way to go. I could, I could in theory do a 45 or 60 minute session where I pack in more, more work per unit time. I'm not going to be able to quote unquote perform as well. I won't be able to lift as much. I'm not going to unweight the bar between sets or maybe even during sets if I have someone who could do that. But it sounds like that's the way to go. So it's got to be so this the old adage of high intensity short duration is probably the way to go. Correct. And you know, in in layman's terms, if the same objective, the same training goal is just muscle tissue growth and we're not talking about maximal strength or any of those type of parameters, we're just talking about growing muscle. If there's an athlete, and they do six six sets of 10 with two minutes rest and there's athlete B that does six sets of 10 with three minutes left rest, athlete A will likely see the highest muscle gain muscle hypertrophy gains because of the metabolic stimulus that they're driving with the short to rest periods. Interesting. For all the years that I've spent exploring exercise science and trying to get this information from the internet and various places that this is the first time it's ever been told to me clearly. So basically I need to put my ego aside and I need to not focus so much on getting as many reps with a given weight and keep the rest restricted two minutes about two minutes. Yeah, get the work in and then I'll derive the benefits. I mean, you've absolutely nailed it to be honest. And again, if you think about human nature and how we approached, we're inherently lazy, right? As humans, we want to take that rest, we want to take the time out to recover and feel refreshed, but we're trying to create a training stimulus. We're trying to create a very specific stimulus internal to the body and that is often driven by the metabolic environment at that moment in time. Now, if we allow the metric up the body environment to change by extending the rest periods, we're not going to see as beneficial gains at the end of it. It is very much a motivational and ego thing rather than saying, okay, I'm going to push my loads as high as I can and really challenge maximum strength to do fewer repetitions, take longer periods of time. It's a completely different approach to training. It's a different end goal. Interesting. And you mentioned lactate. So it seems still a bit controversial as to what actually triggers hypertrophy you hear about. Lactate build up or people that the common language is the muscle gets torn and then repairs, but I don't know does the muscle actually tear? I mean, microchrom and disruption of the mic within the muscle tissue show. Interesting. And we're talking now about non-drug assisted people who's who's let's just say let's define our terms here that whose testosterone levels are within the range of somewhere between 300 and 1500 or whatever 1200. Because it does seem that athletes who take high levels of exogenous and surgeons can do more work and just get protein synthesis from just doing work. I've seen these guys in the gym, right, the hotel signs are not that hard to spot where they're just doing a ton of volume not necessarily moving that much weight. They're just bringing blood into the tissue and then they're loading up on, they're eating a ton of protein presumably because they're basically in puberty part 15. Right, they've gotten their 15th round of puberty where during puberty you are approaching synthesis machine. I mean, that's to me that's pretty clear about puberty. Interesting. And then in terms of, because I know the audience likes to try protocols so that you described a protocol very nicely, what about day to day recovery? The workout that you described is intense, but short, how many days a week can the typical person do that and sustain progress? Yeah, I mean, I think that comes back to your training age and your training history. Obviously, there's a resilience and a robustness with an incremental training age. So, you know, that's not a protocol that I would advise anyone to go out and start tomorrow. They'll be mobbing them off the gym floor. But at the same time, it's also relative, right? So 80% of your maximum at a young training age is still 80% versus, you know, been training 10 years, it's still 80%. But yes, the mechanical load is going to be significant. It's just more tonnage, right? But yeah, I think a protocol like that, we would look at two times a week, something that's pretty intensive like that. Because again, it comes back to the point you make is that you really need to be, for what a better term, suffering a little bit through that type of protocol, both in terms of the challenge of the load, but also being able to tolerate the metabolic stress that you're exposed to. It's a bit of a sicko feeling, right? Because of the lactate that you're driving up. I wouldn't promote an athlete doing that type of modality, you know, multiple, multiple times, unless you're from the realms of bodybuilding, and then you really, that's the sole purpose of what you're trying to achieve. Most athletes in most sports have diverse requirements in terms of outcomes that they're trying to achieve. They're not just targeting muscle growth. Muscle growth is a conduit to increase strength, increase power, increase speed, obviously. So, yes, trying to get big a cross-sectional area of a muscle means that we can produce more force into the ground, or wherever it may be if we're a locomotive athlete. But usually sportsmen and women are not just purely seeking muscle growth. They look for different facets of muscle endurance, or maximum muscle power, muscle strength. So, then you've got to be very creative in how you build the workout. If it's a bodybuilder, absolutely. They're chasing muscle growth, and they're going to do so with these types of protocols, which sees high intensities and high volumes of workload on a pretty regular basis. If it's just somebody, a weekend warrior that wants to keep in shape, and look good, I would say two times a week for a really challenging workout like that, and then flex the other types of workouts within the week to have more of a volume emphasis, where you reduce the intensity, and you might just look at larger rep ranges from 12 to 15 to 20, another workout where you're looking at reducing the volume, but increasing the intensity, and really trying to drive different stimulus to give you more end points of success. Great. Now, that's really informative. Along the lines of Androgens and intensity, when I think intensity, I think epinephrine adrenaline, and since you have a background in catacolomines and testosterone. Last time I was here at the USC Performance Institute, we had a brief conversation, and I want to make sure I got the details right, that in the short term, and a big increase in stress hormone can lead to an increase in testosterone, like a parachute jump. But so stress can promote the release of testosterone. That was news to me. We always hear about stress suppressing testosterone, stress suppressing the immune system, all these terrible things, but in the short term, you're saying it can actually increase the release of testosterone. So I have that right? Correct. And so then the second question is, does my cognitive interpretation of the stressor make a difference? In other words, if I voluntarily jump out of a plane with a parachute, does it have a different effect on my testosterone than if you shove me out of the plane against my will? What presumably with a parachute? So this was what all my PhD work was looking at was the pre-exposure to a stressor, and the pre-arousal of how your body essentially prepares for that stressor, and then how it manages it throughout the exposure to the stress. And it was actually motivated from parachute jumpers. There was an older study looking at parachute jumpers into combat, and they were studying the cortisol, the stress response, and the epinephrine response of these parachute jumpers. So we got us thinking about, hold on, there's certain workouts that you do that are just the daunting. It's like, okay, it's squat saturday or whatever it may be. Oh my gosh, this is going to be a, this is going to destroy me. Or after talk to this person, I don't want to talk to, or something, or a PhD dissertation exam or something. We've been public speaking, whatever it may be. Now, we used an exercise, we used a resistance training protocol that these athletes knew was going to be very, very challenging. It's going to be, there's going to have some anxiety to doing it, then knew there were going to be some physical distress from doing it. And therefore, you know, their mindset of how they were going to approach that was already set. So what we saw prior, 50 minutes prior to the start of an exposure to the workout, the epinephrine, the neurodrenaline, the adrenaline was already starting to prepare the body sympathetically, and to go into what it knew was going to be a very, very challenging workout. So that brings you back to exercise preparation, competition for certain preparation preparation for certain competition, excuse me, pre workout routines, the use of music, you know, all these different things that we know can now, you know, anecdotally in the gym, we put into place, but the data that I presented to show that it was the first of its kind to show that this link between, you know, epinephrine and neuropinephrine release and arousal. And then consequent performance, so force output throughout the, throughout the workout was intimately linked. So what's the, what was the takeaway there should, is it beneficial for people to get a little stressed about the upcoming impending event, whether or not it's a lift in the gym or whether or not it's talking to somebody that you might be intimidated to talk to or an exam, is it is the stress good for performance or is it harmful? Yeah, and I think that's a great question, and I think I can only talk to, you know, physical exertion, which is what we were exploring and I don't want to try to the toes of the psychologist with flow state and these types of things because clearly, I think you're in the position of scientific strength on this one, I think you have the leverage. I mean, most, you know, I have a lot of friends in that community, as I'll just say, as a buffer to your, the answer you're about to give that there's, there's very little science around flow and there's very little neuroscience related to most psychological states anyway. So I think we've got a lot of degrees of freedom here. All right, I can breathe these. Thank you for that. Yeah, I'll take, I'll, I'll be anything you like, credit Duncan, anything you dislike, send the, send the mean comments to me. Yeah, I think from, from my data, certainly, the, the greater the rousal, the higher the performance was from a, from a physical exertion perspective, and I think that was the intriguing part of some of my findings with definitely a bio, an individual bio kinetics to some of these hormonal kind of releases. And as much as those guys that had the highest, you know, adjunior response in terms of epinephrine release, nor epinephrine release also sustained force output through for a longer period of the workout than those that didn't. So the, the, the individuals are at a lower stimulus of the sympathetic arousal, let's say, certainly didn't perform as well throughout the work. Now, the intriguing thing then becomes is okay, and I think this, this, you know, really segues into what, what we're doing here with, with combat athletes with mixed martial artists, you know, there's a philosophy, there's a paradigm now from a self in terms of the exposure, repeat exposure, you know, the more you do that challenging workout, do you get the same psychological stimulus, do you get the same stress response. And, and the assumption is unlikely, you know, you accommodate, you become accustomed to the stress, your body will therefore adapt, and that's the classic overload principle, right. You then need to take the stress down a different route, but I think when you look at, you know, the athletes that we work with here, it's a fistfight at the end of the day, that's, there's nothing more stressful of now. I think just the exposure to the rigors of training, to understand the bad positions, the bad situations, to know that they can get out of certain situations that have certain, you know, submission holes or whatever it may be. I think that really ties in with some of my PhD work in terms of what these guys do to approach, what is, you know, really challenging sport and arena in mixed martial arts. Yeah, it's definitely the extreme of what's possible in terms of asking does stress favor or hinder performance, because yeah, like you said, at the end of the day, it's someone trying to hurt you as much as they possibly can within the bounds of the rules, and you're trying to do the same. So that's, you know, I find that your thesis worked fascinating. Where you never to be at the, you have to see performance institute, luckily they made the right choice and brought you here, but where you have never to come here, I was still fascinated by this because over and over, we hear that stress is bad, stress is bad, stress is bad, but everything I read from the scientific literature is that stress and epinephrine in particular is coupled to the testosterone response to performance and to adaptation provided it doesn't go on too long. So unless I'm saying something that violates that, I mean, that's your work, so it's really important and beautiful work, and I refer to it often, so I'm just glad that I think we could, you know, bolt that down because I think the people need to know this that that discomfort is beneficial. Now there's another side to this that I want to ask about, which is the use of cold in particular things like ice baths, cold showers, or any other type of cold temperature exposure, you know, in theory, that stress also, it's epinephrine. And so how should one think about the use of cold for recovery, so if it's stress, how is, if stress, if cold causes stress, then how is cold used for recovery? That's what I don't understand and maybe you just want to share your thoughts on that. Yeah, no, and I think, you know, it's a great question, and I think the jury is still out there certainly knowing some of the conversations that we've been having, but I think, you know, when we talk about stress, it's your classic fight flight of freeze approach, and, you know, throwing your body into, you know, a cold tub, a nice bath, or whatever it may be, certainly is going to have a physiological stress response. Now people are using that for different end goals, and again, I think that's where the narrative has to be explained. If you are using that stress specifically to manage the mindset, to use it as a specific stress stimulus, that's the same as me doing six by 10, 80%. You know, you're just trying to find something to disrupt the system to do something that's very, if you want to better term, painful, discomfort, whatever, you're just finding a stresser and then being able to manage the mindset. But if you're using cold specifically from a physiological perspective to promote, you know, redistribution of vascular, you know, of blood flow, you know, to different vascular areas of muscle that you feel have gone through a workout that are damaged or whatever it may be. I think there's, we've got to understand what that stress mechanism is, and, you know, the data, the literature is certainly still out there with respect to cryotherapy and cold baths, and some of these, you know, high, these cold exposures in terms of what they do at the level of the muscle tissue. If that's the target, if you're trying to promote a flushing mechanism or you're trying to promote redistribution of the blood flow, what you've got to understand is that cold is going to clamp down every part of the vascular system, and we've really got to understand how the muscle would be redistributed to areas of interest. So, you know, I think the stress response is a real thing with respect to cold exposure, but I think the narrative around what are you using the cold for has to precede the conversation, because yes, it's, you know, it's like putting your hand over a hot cold. You know, that's a stress the same way as jumping in a cold bath is. I think most people don't realize that you're going to get the up and effort and release from holding your hand up to close the flame, and you're going to get it from getting in the ice bag. Your body doesn't know the difference, right? Your body does not know the difference. It has a, you know, a primordial kind of physiological response that it's created over millions and millions of years, and I think that that's that physiology is is not changing, and it's fixed in a particular way right now. And that it doesn't understand the difference between whether it's six by 10 doing a challenging workout over here, whether it's put my hands on the hot cold, whether it's a lion stood in front of me or whatever that epinephine response from the level of the brain down to the whole signal in cascade is the same. And cold, I've heard can actually prevent some of the beneficial effects of training that it can actually get in the way of muscle growth, etc. Yeah, there's some pretty robust dates out there now showing that it definitely has an influence on performance variables like strength and power in particular, but absolutely in terms of muscle hypertrophy. And there's a big kind of theme in the world of athletic performance right now in terms of periodization of cold exposure as a recovery modality. What when do you use cold, you know, should you be using cold for recovery in periods of high training load when you're actually pursuing, you know, maybe general proprietary for priority work, we're actually trying to pursue muscle growth. Well, that's usually where you get the most sore. It's usually where, you know, you feel the most fatigued, but it's probably not the most beneficial approach to use an ice bath in that in that scenario because you're dampening you're dulling the you know, the amtop pathway and the high put high putrophic. And signaling pathway, whereas in a competition phase, where actually quality of exercise and quality of execution of skill and technical work has to be maintained. You want to throw the kitchen sink of recovery, capabilities and recovery interventions in that scenario because you know, you know, the muscle building activity should be in the bank that should have been done in the general preparatory work and now you're focusing on technical execution. So you're absolutely right. It's interesting. So if I if I understand correctly, if if I want to maximize muscle growth or power or, you know, improvements and adaptations, then the inflammation response, the delay on set muscle soreness, all the stuff that's uncomfortable and that we hear is so terrible is actually the stimulus for adaptation. And so using cold in that situation might short circuit my progress, but if I'm, you know, I don't know that I'll ever do this, but if I were to do an iron man or something or run a marathon under those conditions, I'm basically coming to the to the race. So to speak with all the power and strength I'm going to have and so they're reducing inflammation is good because it's going to allow me to perform more work. Absolutely. Yeah, you have to be strategic about when you use some of these interventions and you know, the the time when you're preparing for a competition is not the appropriate time. Excuse me, is the appropriate time when you want to drive recovery and make sure that your body is optimized. And you know, when you're far away from a competition, you know, date or you know, out of season or whatever it may be and you're really trying to just tear up the body a little bit to allow it to its natural, you know, healing and adaptation processes to take place. Well, you don't want to negate that, you know, you want the body to optimize its internal recovery and that's how muscle growth is going to happen. So interesting that there's a time kind of consideration that you need to make with these interventions for sure. At the USC Performance Center are the fighters periodizing their cold exposure or are they just you doing cold at will. Well, it's not just the UFC and again, I talk about my personal experiences with different sports. I think just education around where scientists are and that understanding of concepts like the use of cold exposure for recovery, ice bath, you know, everyone wants to jump in an ice bath. So I think as we've as we've stepped back and scientists have started to say, I've started to figure out and look at some of the data, you know, we're now more intuitive about well actually that might not be the best of the most optimal approach. And I think that's that any given sport. So yes, certainly here at the UFC, we're trying to educate our athletes around, you know, appropriate timing. And it's the same with nutrition. And it's the same with an ice bath intervention. It's the same with lifting weights. It's the same with going for a runner working out on the bike. There's tactics to when you do things and when you don't do things. And I think, you know, stress and cold exposure. We have to have a consideration around that as well. But it's not just, you know, MMA fighters. That's any athlete. And I think it's the best professionals, the most successful professionals do that really well. They listen number one, they educate themselves and then they build structure. And I think, you know, at the most elite level, we always talk about it here at the UFC, but the most elite level, you're not necessarily training harder than anybody else. Everybody in the UFC trains hard like everyone is training super hard. But the best athletes, the true elite levels are the ones that can do it again and again and again on a daily basis and sustain a technical output for skill development. Therefore, their skills can improve or physical development, their physical attributes can improve. So that ability to reproduce on a day-to-day basis falls into a recovery conversation. Now, when is the right time to use something like an ice bath and when is it part of the high performance conversation for sure? Really, they're scientists, they're building structure, they're figuring out variables. But it sounds like the ability to do more quality work over time is one of the key areas. I mean, it's fundamental. I mean, garbage in, garbage out, quality in, quality out. But in our sport, you know, I talk about, you know, mixed martial arts, it's truly a decathlon of combat. So there's so many different attributes, whether it's a grappling, whether it's a wrestling, whether it's the transition work, whether it's a stand-up striking. So the different facets of a training program in this sport are significantly large compared to something like, you know, a wide receiver in football. And there's no disrespect for wide receivers, but they run routes. They're going to run a route of a pass in tree and that's all they need to do. These guys have to be on the ground. They've got to be great standing up. They've got to be great with the back against the fence. So there's so many different kind of facets to our sport. So managing the distribution of all the training components is one of the biggest challenges of mixed martial arts. And the best guys get that right. They allow their body to optimize the training. And remember why are we doing training? We're doing training for technical and tactical improvement. Now if your body is fatigued or you just can't expose yourself to more tactical development or technical development, then you essentially doing yourself a disservice. You're going to be behind the curve with respect to those guys that can reproduce that day and day out. On the topic of skill development, regardless of sport, we hear all the time. And it certainly is intuitive to me that the person who can focus the best will progress the fastest. But it's kind of interesting. Sometimes I talk to athletes and they seem a little bit laid back about their training sometime. And yet they obviously know how to flip the switch and they can really dial in the intensity. Do you think that there are optimal protocols for skill learning in terms of physical skill learning? Like could it ever be parameterized like the six sets of 10 reps? And this gets to the heart of neuroplasticity, which is still, you know, it's not a black box, but it's kind of a black box with portions of it illuminated. I like to say, but what are your thoughts on skill development? Is there for somebody that wants to get better at sport? Do you recommend a particularly long or short training session? It does intensity matter? Or is it just reps? Yeah, I think no, it's not a volume driven exercise. It's a quality driven exercise. And listen, my expertise is not in motor learning and motor skill acquisition. I tend to default to Gabriela Wolf here at UNLV for that. She's one of the leading proponents in this area. But you know, if you look at true skill development, it is about rehearsal of accurate movement, accurate movement mechanics. And as soon as that becomes impacted by fatigue or inaccurate movement, you're now losing the motor learning. You're losing the accuracy of the skill that people can call it muscle memory or whatever they want. But essentially you're grooving neural axons to create movement patterns and their situational throughout sport, right? You know, whether it's a croif turn in soccer or a jump shot in basketball or a forehand down the line, you can carve out that particular posture and position and skill and you can isolate it. And you can drill it again and again and again. I was soon as fatigue is influencing that repetition. It's time to stop. And the best coaches understand that. They understand that it's quality over quantity when it comes to skill acquisition. So to answer your question in a roundabout way, I would say yes, it's shorter sessions that are very high quality. And I think the best athletes in my experience are the ones that consciously and cognitively are aware of it every moment of the training session. They should they should leave the training session not necessarily just physically fatigue, but mentally fatigued because they're completely engaged in the learning process. So the problem then becomes okay, if we just do lots of, you know, 30 minute sessions, we've got to do a lot of 30 minute sessions to get the volume exposure of the repetition and the rehearsal of this skill again and again and again. So the bit of a paradox is a bit of a double edge sword. But you know, a three hour session versus a 90 minute session, you know, we'll take the 90 minute session any day when it comes to skill acquisition because that's going to be driven by quality over quantity. Training and skill learning is incredibly mentally fatiguing. I've often wondered why when one works out hard when it's with, you know, Ron or with the weights, why it's hard to think later in the day. Right. Yeah, it really there really does seem to be something to it. And I've wondered is it depletion of adrenaline dopamine. I sometimes think it might be dopamine. And here I'm totally speculating on it. I have any data to support this. But if you hit a really hard workout or run early in the day, oftentimes the brain just doesn't want to do hard mental work, which gives me great admiration for these athletes that are drilling their mind and body all all day every day. With breaks, but so what are your thoughts? What what what leads to the mental fatigue after physical performance? Well, again, I don't want to talk out, you know, talking to the man here, you know, this is where we're just too scientists speculating on this point up until now we've been you've been giving us concrete. Pure reviewed study based feedback on my questions, but but if we were to speculate, I mean, I think this is a common occurrence. People think if I get that really good workout in in the morning, I feel better all day. That's true unless that workout is is really intense or really long. And then you just the mind just somehow won't latch on to mental work quite quite as well. I mean, just philosophically, and I think there's a coming back to this kind of stress consideration, you know, like a public speaking or taking an exam. I mean, if you're if if you have an amazing coach, you were setting up training in a particular way, it's challenging it. There's a strain related to it. And I'm not talking physical strain. I'm talking figuring things out, you know, figuring out the skill. And I think that can be stressful like the learning process can be stressful. So, you know, we've touched on stress. I also think if they if they if they if they hit the right technique, you know, that reward center in the brain, that dopamine shot is is going to fly up there. And there's only so many times that we can get that before it that becomes dampened. And I think there's an energetic piece to it. You know, there's the fueling of the brain. There's the there's the the carbohydrate fuel and exercise that actually the strategy around how you fuel for learning and fuel for physical training is actually pretty similar glucose. Yeah, it's glucose. It's sugar at the end of the day, right. And so, you know, are you are you are you fueling accordingly around your training sessions be that very physical because everyone thinks, OK, you know, I'm going to jump on the treadmill and I'm going to bang out, you know, 15 sprints at max effort. And I'm going to, you know, be dropping off and lying on the floor at the end of it, I need to refuel. Well, what about the refueling of the brain in a very demanding exercise or drilling session where you're looking at technique that you're trying to figure out this very challenging for your mind to figure out the complexity of it, but still needs to be fueled or refueled afterwards. And I think that's obviously, you know, it might be an area where athletes do themselves a disservice by not appropriately fueling from what might be considered to be a lower intensity session, but the cognitive challenge has been significantly high. So they're doing skill work or drill work and it's taxing the brain and they're thinking, oh, you know, I wasn't, you know, pushing hard lifts or doing sprints. And so I can just go off and the rest of my day. But then their, their mind is drifting. Yeah, I speculate. Yeah, that seems very reasonable. I mean, I know that I'm here and presumably with the other athletes, you've worked with nutrition is a huge aspect of that. And I think the general public can learn a lot from athletic nutrition because at the end of the day, the general public is trying to attend to their kids, attend to their work, whether they're lawyers or whatever. And they need to focus nutrition is a barbed wire topic. Oh, yeah. But if since we're free to do what we would do if we were just sitting in each other's offices, which is to just speculate a bit for the typical person. Do you think these low carbohydrate diets, typical person who exercises run swims yoga lifts weights, maybe not all those things, but some collection of those is pushes themselves to do those things and to do them well, but isn't necessarily a highly competitive athlete. Do you think that nutrition that doesn't include a lot of glucose doesn't include a lot of carbohydrates is a problem or is it okay. What do you recommend for athletes? What do you recommend for typical people? Yeah, again, disclaimer. I'm not a dietitian. But I don't get the dietitians don't know what to recommend. And I say that from having spent a lot of time with the literature now, it's a complete mass. Yeah, it's like I thought we didn't understand anything about the brain. The nutrition science stuff is all over the place. So I think we have again a lot of degrees of freedom. I mean, I think it comes down to metabolic efficiency. So we would never we would never advocate a high, I never say never, okay. But we rarely advocate a high performance athlete in a high intensity intermittent sport like MMA, being totally ketogenic or be not recommended. No, because at the end of the day, some of those high intensity efforts usually require, you know, carbohydrate fueling for the high and the energy. The energy is produced at those high intensity. So we try to navigate around that. Now, the listen, there are fighters in the UFC and elsewhere. Matt Brown is a great example. He was, you know, promotes the ketogenic approach and it works for him. But we look at the science and the nature, the characteristics of us for and we don't necessarily promote that. Can I interrupt you real quick? What about ketones for people that are ingesting carbohydrates? This is an interesting area because people always hear ketones and they think I have to be ketogenic to benefit from taking ketones. Right. But there are a number of athletes and recreational athletes now as well, taking liquid or powder based ketones on even though they do eat rice and oatmeal and bread and other things. So, are there any known benefits of ketones, even if one is not in a state of ketosis? So the only, the use of ketones that I'm primarily aware of is in our sport is after the event, you know, in terms of the brain health with athletes that are potentially taking trauma to the brain, etc. and looking to maintain the fueling and the energy supply to the brain. But yes, it's probably a little bit out of my remit. So I don't want to talk on that because I'm not fully familiar with that. Well, I've heard that ketones after head injury can provide a buffering component. Correct. It's not going to reverse brain damage, but it might be able to offset some of the micro damage. Right. So that's what, that's how we use it. Just to sustain, you know, the energy supply to the brain that might be compromised through brain trauma. So that's why we use ketones. And to come back to your original question, if it's, you know, general population, then yes, I think there's a place to argue that actually being on a ketogenic diet at times, and maybe that's a cycling exercise, maybe not, you know, I don't mean cycling a bike. I mean, cycling ketosis is beneficial because I think it's going to lead to better metabolic management and better body proficiency. Those lower intensities where we should be fueling our metabolism with lipids and bats, clearly the western diet and, you know, the modern day diet is heavily driven by processed food and carbohydrates that, you know, people become predisposed to utilization of that fuel source above lipid use fat use intensities that are very low. So, you know, some of our data with the fighters shows that as well. But I think the challenge for us is that we're working with a clientele that require high intensity, about some effort. So, you know, fueling appropriately is very important for that. Now we use, we use tactics here where we essentially have athletes on what you would say kind of a, is it a larger ketogenic diet. But then we will fuel carbohydrates around training sessions. So, we'll do very timed exposure to carbohydrates. So, it's not post training. Post training immediately pre-juring and then immediately post. And then the rest of their diets, you know, breakfast, lunch and dinner, what would look like ketogenic type approaches. So, we're trying to be very tactical in the exposure to maximize the intensity for the training and then return to a metabolically efficient diet, which is heavily reduced in carbohydrate, because we're fueled the sessions that need it. So, I'm smiling because once again, this place, the UFC Performance Center is doing things scientifically, which, you know, to me, the idea, and I'm pleased to hear that, because to me, this idea that the ketogenic diet is the best and only diet, or carbohydrates and low protein diets are the best diet. It's ludicrous. Then you mentioned metabolic efficiency. I think some people might be familiar with that term, some perhaps not. But the way I understand metabolic efficiency is that you teach the body to use fats by maybe doing long, long bouts of cardio, maybe lowering carbohydrates a bit. So, teaching the body to tap into its fat stores for certain periods of training. And then you also teach the body to utilize carbohydrates by supplying carbohydrates immediately after training and before training. You teach the body to use ketones. And then you use them at the appropriate time, as opposed to just deciding that one of these fuel sources is good and all the others are bad or dispensable. Do I have that correct? You nailed it. Bob C. Bajar, formerly of USA Triathlon, is the guy that kind of came up with the concept of metabolic efficiency. But yes, you're absolutely right. I mean, low intensities of exercise or just day-to-day living, we shouldn't be tapping into our carbohydrate fuel sources extensively. That's for higher intensity work or the fight or flight needs of stress. If athletes or any individual has a high carbohydrate diet, they're going to start to become predisposed to utilizing that fuel source preferentially. Now, low intensity, that can be problematic. Certainly for an athlete, because if they preferentially use carbohydrate at lower intensities, when the exercise demand goes to a higher intensity, they've already exhausted their fuel stores. They can't draw upon fat because the oxidization of that fat is just too slow. So they're essentially now become fatigued because they've already utilized the carbohydrate stores. So what we try to do, yes, through diet manipulation and a little bit of exercise manipulation is as you say, teach the body or train the body to preferentially use a specific fuel source, fat obviously at lower intensities and carbohydrate at high intensities. And we look at specifically the crossover point between the two, tells a lot in terms of how an athlete is ultimately, how their metabolism is working. Again, I'm smiling because I love this because it's grounded in something real and scientific, which is that we have these different fuel sources. The body can adapt to use any number of them or one of them. So we're looking for that one pattern of eating, that one pattern of exercising that's going to be best for them or sustain them. And they often look back to the time when they felt so much better switching from one thing to the next, but the adaptation process itself is also key, right, teaching the body. So if we were to just riff on this just a little bit further, if somebody, I'll use myself as an example, since I can only speculate what other people's current nutrition protocols are. But if somebody is eating in a particular way and they want to try this kind of periodization of nutrition, could one say, okay, for a few weeks, I'm going to do more high intensity interval training and weight training and I'm going to eat a little bit more carbohydrate because I'm depleting more glycogen. Then if I switch to a phase of my training where I'm doing some longer runs, maybe I'm not, maybe I'm training less, maybe I'm just working at my desk a little bit more. So I might switch to a lower carbohydrate diet, do I have that right? And then if I'm going to enter a competition of some sort, certainly not UFC or MMA of any kind to be clear. Not because it isn't a wonderful sport, but because that wouldn't be good for my other profession. But if I were going to do that, then I would think about stacking carbohydrates, ketones and fats. Do I have that more? I mean, I think, yeah, you don't set it eloquently. At the end of the day, you're consciously understanding what the exposure to physical exertion is and you're flexing your diet accordingly. So it's need-based eating. Exactly. For one of our veterans, you can call it whatever fancy terminology there is out there. But yes, it's needs-based eating. But you're very conscious and cognizant of what is my current exercise status. If I'm taking some time off, then don't go on the carbohydrates. We probably need to be, it's going to be lower intensity work or even just habitual day-to-day walking around doing your groceries. That doesn't require massive amounts of glycogen storage and carbohydrate fueling. So you can potentially go more ketogenic in nature, oxidizing lipids for that fuel. If you are in a high period of high intensity training, then you have to consciously flex your diet to support that. That's not normal. You've made a change, you've elevated the demands. So the fueling requirements for the regenerative- not only fuel in the exercise, but the regenerative requirements of your body after that type of work is going to be really important as well. So yes, take on more carbohydrates. So I think it's consciously interpreting the nature of your diet against where you are at any moment in time. Like that. I think the listeners of my podcast generally are experimenters. They are scientists of themselves, which makes me happy obviously. And I like to think that they're paying attention to the changes they're making and how they're affecting themselves. And they seem more open to trying things, but why they can do it safely. And seeing what works for them. And I'm certainly going to try some of the change up. I also am really a creature of habit. And I think the talking to you today, I realize I'm probably doing a number of things truly wrong in my training, but also that I don't tend to vary my nutrition with my training quite as much as I should. I'm just locked into a protocol. We covered a number of things related to your PhD thesis work. And then, but I cut you off early on related to your trajectory. After you finished your thesis, you, I know you were at Notre Dame for a while. Was that your first spot after your PhD thesis? No, no. I basically finished my PhD and I dropped into the British Olympic system for about 14 years. Oh, my. I was with, you know, I've done three full Olympic cycles with different sports and largely strengthened conditioning coach as a practitioner. I was always working in universities in academia alongside, you know, in terms of continuing to publish and write and do research and teach as well. That explains the youth volume of publication. I don't think people realize a lot of the work that goes into getting a quality peer reviewed publication. It's not what what do they call it now on Instagram, Annika data where people do something what, you know, they have this experience and then they put in the world that it's an I don't know that we get to call it data, but so 14 years in that working with the British Olympic team. Yeah, so with, you know, whether it was GB boxing primarily with the, with the, the reo, excuse me, the Beijing cycle, but also lightweight rowers and gymnastics. The London Olympic Games that cycle was with I was the lead stranding condition in a physical performance coach for British basketball, so GB basketball. I had about three years in the English Premier League and with with Newcastle United and the soccer team. And then for the reo Olympic cycle, I was with great Britain Taekwondo. So again, another combat sport. I've finished there. I kind of moved to the University of Notre Dame where I went into more of a more of a managerial position working across all the different technical services, medical, nutrition, stranding, conditioning, you know, psychology, whatever sports science, whatever it may be. As the director of performance sciences for Notre Dame athletics, and then after about 16 months there, the UFC came knocking and they recruited me out of Notre Dame. So it's been a great ride and lots of, you know, I've got, you know, lots of athletes have taught me a lot along the way, lots of coaches, you know, every day is a school day. I still try and keep that mentality and, you know, in this world, we call it white belt mentality, you know, it's, you know, I'm a PhD. I've got 25 years of experience in high performance sport, but I still, I still learn every single day from these people out on the mats and in the ring. And it's impressive to see what they do. Yeah, certainly is I got introduced to MMA just a few years ago. I think the first time I came out here was one of the first times I had heard of MMA because I was kind of in my laboratory and, you know, knows down. And it's a really interesting sport because they incorporate so many different types of movement. As you said, you know, it's not just stand up boxing. It's just kicking is ever, you know, ground game, everything. And I'm still learning about it. But as you mentioned going in with that beginner's mind, the white, white belt mentality. What what has been the most surprising thing for you in terms of being exposed to MMA in particular as opposed to other sports, like what's what's unique about MMA fighters besides that they have this huge variety of of tactical skills that they have to learn and perfect. Yeah, that's a great question. I would say two thing I'm going to answer two questions. One actually reiterates what you've already said, like the degrees of freedom in mixed martial arts are exponential like know the sport, you know, we've got 11 different white classes. We have men's classes, we have women's classes, we have, you know, kickboxes, wrestlers, juditsu fighters, judokas, you know, like karate fighters, you know, the stylistic backgrounds are infinite. We have, we're a weight classification sport. There's a whole issue relating to making weight and then rebounding to fight about 24 to 30 hours, like just the variability in this sport, the considerations that you have to make are unprecedented compared to any other sport that I've worked with. And a lot of them go against and they are the antithesis of what you would expect for high performance, you know, in terms of we don't always have a very clearly defined competition schedule. You know, once these guys fight, they don't necessarily know when their next fight is going to be. What's the closest spacing of a fight? I mean, listen, I think the record is around, it's just over a month, I believe. So, you know, that's a quick turnaround, but most of these guys are fighting, you know, three or four times a year, three times a year is pretty normal. The bigger fights, maybe two times a year. But invariably the guys don't know when that next date is going to be. So we're in this gray area of, okay, what do we do? Like are we taking some time off or we're just going to do some general prep work? Are we going to try and keep this, you know, the knife sharpened in case I get, I didn't realize this. In that way, it's a lot like special operations. Absolutely. You don't know when the call is going to have. They have to be ready at all times. There isn't this like, let's get ready for the season. Yeah, like when I was with the British Olympic Association, you know, I knew it was the British Open, the Spanish Open, the French Open, the European Championships. They're really open, the American Open, the Canadian Open, the Olympic Games. It's a circuit in your brain. Right. You just plan like, you know, where all the targets are going to be. Here, it's a moving target because you might be just hanging out doing some general prep work. And then you might get a short notice fight. They give you a quick call and send six weeks or five weeks. Okay, I've got to ramp everything up really quickly. So that's a real challenge in terms of just managing all these, these different components of mixed martial arts along. The other, to come back to your question, the other thing which is truly fascinating about these individuals is the, just their mental resilience. And again, we've touched on it in the talk, but you know, the ability to do what they do on a daily basis to look at all the different skill sets that they have to try and engage in and bring into their training to do that and embrace the ground and brace the process of just learning. The physical side of our sport is unprecedented, but the mental side, you know, we haven't funny say any. We always say it's 90% medical at 90% mental apart from the 60% is physical. So you know, it's just, it's just more and more and more. And these guys ability to just do that on a daily basis is very impressive. Like the resilience that their internal drive and their resilience is really impressive to see. You know, all the fires I've met here have been really terrific. It's interesting. Every time I meet a fighter, how often I, I shouldn't be surprising where they're often very soft spoken. Right. Always extremely polite. Yeah. And fighting is such a, you know, it comes from a very primitive portion of the brain, right? It is, but a large portion of the brain. But I think that's another skill is that switch. You know, and again, that's the recoverability piece, right? Like you cannot be type A or you cannot be like super charged 24 hours a day. Because you're going to just fry your system, right? And I think that's something else where we're really trying to manage this whole process. Be it through nutritional interventions, be it through education, run sleep, be it through training program management, be it through psychological interventions. You know, you could look at fights and say like these guys are go like they're red alert and they'll run through a brick wall. But actually, again, their ability to turn it on and off means that they can do what they do. You know, they can bring it down and be very normal, very polite, very accommodating. Maybe even better than most people because you know, one of the reasons I'm obsessed with human performance and high performance and people like fighters and elite military or, or even bodybuilders for that matter is that they, they experiment. Yeah, they find the outer limits of what's possible. But one of the things that they have discovered as you're describing is this ability to toggle between higher alert states and calm states. Most typical people can't do this. They see something that sets them on the internet or something on the news or some external event pressures down on them and they're stressed for many, many days and weeks and sometimes it goes pathological, right? And this, I don't say this as a criticism. It's just that most, most human beings within our species, most members of our species never learn to, to either flip the switch or to just voluntarily toggle between states. I think athletes learn how to do that extremely well. And it sounds like MMA fighters do that even better than perhaps many other athletes. I mean, yeah, there's the odd one or two that would struggle with, but I think in terms of that chronic exposure, we see that come in from challenges around cyclical weight cutting and metabolic disruption and metabolic injury, not necessarily from the psychological drive. They do understand that this is a job for them and the time on the mats, most of them can turn it off a little bit and downgrade things when they're off the mats. It's impressive to see. Because again, as a layman just looking at the fight game, you think it's going to be crazy chaotic, 100 miles an hour, every hour of every day. But that's clearly not the case. They manage their energy and their efforts pretty well. It's just a little bit like science, although maybe scientists could take a lesson from. Yeah, evidence practice, practice based evidence. That's good. A couple more questions. I can't help myself. I know we talked about temperature earlier when we discussed cold, but I can't help myself. I have to ask you about heat because earlier we were having a conversation about heat adaptation about how long does it take for the human body or athlete or typical person that's maybe exploring sauna or things that sort. To learn to be a better sweater. It sounds like something none of us would want to do. We all want to say cool, calm and collected. But one of the reasons to deliberately expose oneself to heat is for things like growth hormone release, et cetera. We talk about this, but a couple of questions. One is heat exposure stress in the same way that the ice bath or cold exposure of stress. The second one is is there any difference there that's important. And the other one is how does one get better at heat adaptation or at least what are you doing with the fighters to get them better at dealing with heat? How long does that take? So the first question just because I threw three questions at you is was, you know, is heat stress like cold as stress? Yeah, I think it is. And I think, you know, heat shock proteins, for example, are driven by that stressful exposure to a changing environment. So I think, you know, it's we do graded response in terms of heat acclimation strategies. But yes, we've touched on it earlier in the conversation. For me, heat is still a stressor. And if it's managed incorrectly, you can have detrimental responses rather than beneficial responses. So barring like hyperthermia and death, like I mean, obviously heat up the brain too much people have seizures and die, but you lose neurons. But what's the right way to acclimate heat? Taking into account that people are, you know, to check with their doctor, et cetera, we do all these disclaimers. But, you know, but let's say I, let's just say I want to get better at dealing with heat or I want to extract more benefit from heat. Is, I mean, how many minutes a day are people typically exposing themselves to heat? How often and over how what periods of time? Yeah, so we, we, we, we normally start with about 15 minutes of exposure. Now if someone's really lacking acclimation to heat, you know, you can do that in three, five minute efforts. You know what I mean? And actually take it to hot sauna. Yeah, hot sauna. Take time to step 100 degrees or something like that. Yeah, yeah, 200 Fahrenheit. Yes. And we, we, we try to work up to 30 to 40 minutes to 45 minutes in the sauna. Continuous. Now we have to understand, you know, what, what's the advantage of heat acclimation for our athletes? Ultimately, their ability to sweat and to lose, you know, body fluids is going to be advantageous to their weight cut process, their ability to make weight. It is a technique that these guys, some of these guys adopt. So if you don't have, you know, high sweat rates, it means you're going to have to sit in the sauna for longer and longer and longer to get the same delta in sweat release. And so the more acclimated you are, the more your body is thermogenically adapted, the more sweat glands you have, the more pores, you, you can sweat more and therefore you'll lose that fluid quicker and you spend less time in the sauna. So that's why we do it and to try and promote the limit, to limit the exposure and it comes back to your first question, is it a stressor? It's, it's absolutely it's a stressor if you've got to spend, you know, two hours over, you know, over a four hour period, two hours of it sat in a sauna because you just don't. Where the phone doesn't work so you can't, you know, just, you know, just worse them from their phone and that's a stressor in itself. Right. I mean, yes, I think, you know, there's, there's a, you know, what we do is we, like anything, we build up in temperature, but we build up in volume of exposure. So, you know, we start with 15 minutes and then we just try to add on and add on across the time. And now, now for us, we kind of found about 14 sauna exposures starts to really then drive the adaptations that we're looking for. So it's not a quick fix, you know, a heat acclamation strategy has to happen long before fight week or long before the fights, you know, this is a, this is a process that has to begin, you know, eight to 10 weeks before the fight so that we can actually get that adaptation and that tolerance to the stressor to the exposure of heat. So, what I'm interested in is, I, until today, when we talk about this earlier and again now, I didn't realize that, but it makes perfect sense now that I hear it, that heat adaptation is possible, that you're basically can train the body to become better at cooling itself, which is what sweating is. I mean, I should have known that before, but, you know, you don't see that in the textbooks. So, yeah, I mean, listen, it's, it's, it's the same as the ketogenic conversation, you know, you're training your body to be more better at metabolic efficient, you're training your body to tolerate heat more, you're training your body, like the body is, you know, as an organism, as an organic system, it's, it's hugely adaptable, it's hugely plastic, but I think the skill is understanding the when's the wise and the where of's in terms of changing the overload, changing the stimulus to drive specific at the time. And philosophically, that's, that's how we go about our work here. We talk about adaptation led programming now adaptation led programming fits into every single category, not just lifting weights or running track, it fits into nutrition, it fits into sitting in the sauna, it fits into being in a cold bath or not, it fits into so many different things because we're driven by scientific insights. And that's how we really want to go about our business. I love it. I love this concept of adaptation led programming and doing that, not just in the context of, you know, throwing another plate on the bar or something like that, but in every aspect of one's training and performance. And I think there's a lot here that's applicable to the recreational athlete too. Yeah, would you say that, you know, what comes to mind is 12 weeks, it feels like 12 weeks is a nice block of time for someone to try something in terms of to try something new, see how they adapt, adapt and then maybe switch to something new. I realize that it's very hard to throw a kind of pan time frame around something, but in terms of if someone wanted to experiment with heat adaptation or experiment with cold adaptation or change up their training regimen or diet and look at metabolic efficiency. Do you think 12 weeks is a good period of time to really give something a thorough go and get and gain an understanding of how well or how poorly something works for oneself or would you say eight is enough for three. I mean, that's how long is a piece of string kind of response, right? I mean, yes, if we're just talking arbitrary, recreational experiment, three months exposure, 12 week training, you know, strategy, 12 week intervention is more than adequate to say. For 99% of things that change within the body that physiologically adapt to a training stimulus or an overload stimulus, you're going to start to see either regression or progression, you know, beneficial or detrimental effects within three months, absolutely, I would say so. Now listen, I say that and as much as we do training blocks here that are three weeks long, right? That's because of this constraint that sometimes people suddenly have to they get the call to fight. Correct. Yeah. So it's like super condensed and you know in that in that scenario, we're always conscious of is a body of is a body or this individual. Do they have the ability to tolerate that super overload that like super condensed exposure now we might be doing that purposefully we might be trying to do an overreaching strategy where we're really trying to damage or flex something and I don't mean like negatively damage, but like we're trying to damage tissue to really get an adaptive response versus, you know, more drawn out 12 week strategy, which is more coherent, more planned out, more structured in nature. But yeah, for all your listeners, I would say if 12 weeks to engage in a process of, you know, trying to change an adapt your body or expose yourself to something is more than sufficient to see if it's going to be the right approach for you. And I think, you know, the the the the individual interpretation is always has to be considered. And I think that's where it comes back to be a thinking man's athlete or be a thinking man's trainer, like someone that's going through exercise. You have to cogniz consciously understand where your bodies are at any moment in time, you know, you've got to be real with yourself, you can create a journal, create a log of your training, create a log of your feelings, your subjective feedback of, you know, how you felt, your mood, your sleep. Yeah, we try to promote that because again, that's that's parts of this process, you know, maybe 12 weeks for you, but I might get the same responses in eight eight weeks, you know, and I think that's that's another critical theme here is that, you know, we could put 15 guys on the mat and give them the same workout. And there's going to be 15 different responses to that same workout because the human organism is so complex and in nature that it's going to adapt differently, you know, some people will tolerate it, some people are going to be challenged by it, some people have got a metabolic makeup that's going to promote it, some people are metabolically challenged by it, you know, there's, there's just so many different things that we have to consider. That's what we try to do here, it's the cross we bear, is it we try to understand on an individual level how to optimize athletic performance. I think it's terrific and the athletes here are so fortunate to have this and most people out there, I've, you know, I've certainly been trying to encourage people to learn some science and some mechanism and become scientists of their own pursuits, whether or not skill learning or athletic pursuit, etc. As a sort of a final question, what are some things about the UFC or something about the UFC that perhaps people don't know in terms of its overall mission or what you guys are trying to do here? I mean, I think I've become a fan of MMA and I am more and more as time moves on. Some people might be in MMA, some people not into watching MMA. But what are some things that the UFC is interested in and doing that most people might not know about it and certainly I might not know about. Yeah, I mean, I think, you know, we try to be cutting edge, we try to be super progressive, you know, we think we've got an amazing platform here, particularly the Performance Institute to do some really cool things that can inform many different people. Well, that doesn't just mean the 600 or so athletes that are on our global roster. What we're trying to do is influence, you know, global community around optimizing human performance. So, you know, any moment in time, we're engaging in different technologies with different vendors, different partners, you know, exploring opportunities to, you know, learn more, share data, understand what's the best mechanisms for, you know, interpreting your body, interpreting how your body is responding to training, interpreting, you know, nutrition or whatever it may be, we get, we're in a really privileged position to do that. But we've also, you know, hence you've been here today, you know, we're also trying to venture into some really cool areas of science and research that's got applicability that you can take from high performance athletes and apply to yourself to, you know, Joe blow walking down the street, you know, out there. And that is really interesting and that's everything from, you know, whether it's CBD and psychedelics through to different technologies for, you know, thermal monitoring and Bluetooth heart rate monitoring or whatever it may be through to data management, et cetera, and anything between. We've got some great partners on the nutrition side on the psychology side on the data side and I think, you know, we always try to just push the envelope a little bit more. I think we keep our core mission with our athletes, but I think a lot of what we do. Hence your podcast and you know, like an amazing platform you do such a great job of it that, you know, we can all learn and take from, you know, the elite and interpret how it might help us and just in the general population. So I think that's, you know, that's our north star is to provide our athletes the best integrated service of care. And we also want to influence, you know, just the global community and put you the USA at the forefront of that. It's great where you guys are certainly doing it. We can't let the cat out of the bag just yet, but the things that we're gearing up to do with my laboratory and the work together. Hopefully we'll be able to talk about that and share that in the year to come, but that's we're very excited about that. And Duncan, look, you know, I have this filter that I use when I talk to people academics or otherwise, which is, you know, some people they open their mouth and it doesn't make much difference. So when you speak, I learn so much. I'm going to take the protocols that I've heard about today. I'm going to think about how I'm training and how I could train differently and better, how I'm eating, how I could eat differently and better for sake of performance and just in general. Thank you so much for your time. Your scientific expertise, the stuff you're doing in the practical realm. It's immense. So hopefully we can do it again. Thank you. This has been a blast. I appreciate it. And yeah, keep doing what you're doing because I know there's a lot of people out there that love the platform. So thanks for the invite. It's been awesome. Thank you. Thanks so much. Thank you for joining me for my conversation with Dr. Duncan French. I hope you found it as insightful and informative as I did. If you're enjoying this podcast and we're learning from it, please subscribe to our YouTube channel. 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